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MAY 19, 1986

CHEMICAL & ENGINEERING

NEWS

C, chemistry thriving despite changing energy environment
Page 7

Industrial Gases

Little growth expected

A Key Chemicals Review
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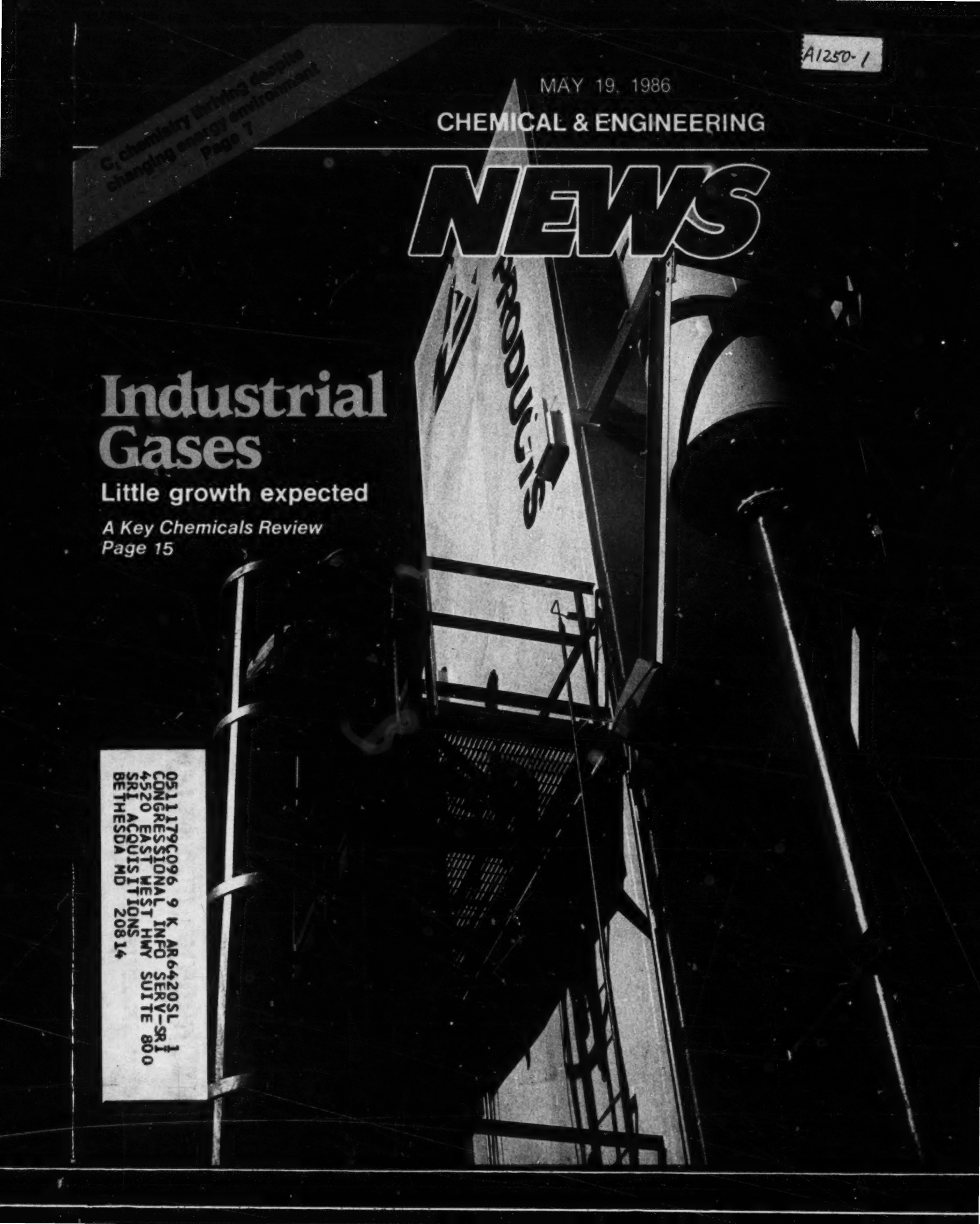

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CHEMICAL & ENGINEERING
NEWS

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MAY 19, 1986

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■ **Investigation of space shuttle *Challenger* disaster reveals series of errors by NASA and Morton Thiokol managements.** **Page 5**

■ **With sale of W. R. Grace's restaurant businesses, chemicals will account for almost 70% of the company's sales.** **Page 5**

■ **EPA okays field-testing genetically engineered bacteria to prevent frost formation on plants, but local opposition arises.** **Page 6**

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Business

Small increase in demand for industrial gases will sustain rise in profit margins, keep plant operating rates high. **Page 15**

Celanese has boosted income despite lower sales, by changes in its organizational structure, R&D emphasis, among others. **Page 19**

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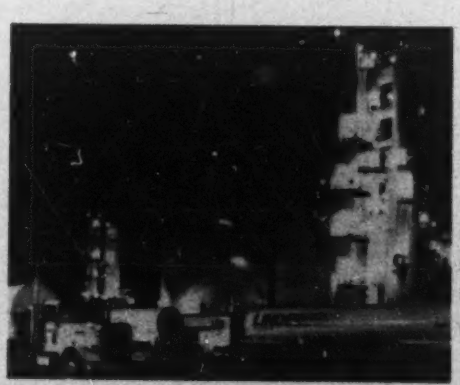


News Focus

C_1 chemistry R&D flourishes, indeed has led to some commercial development, in spite of the fact that the oil shortage that gave the technology its impetus is now an oil glut. **Page 7**

Major Industrial Gases: Demand Edging Upward This Year

Stepped-up demand for uses will help plant capacity utilization and keep profit margins rising; price competition will remain strong

Bruce F. Greek, C&EN Houston

Demand for major-volume industrial gases will swing upward slightly this year because most large uses of nitrogen, oxygen, carbon dioxide, argon, and hydrogen, as well as many small uses, will increase. Capacity utilization of most plants will be high, including the new plants started up last year and early this year.

Price competition will remain strong and not damage margins, as producers further emphasize the service aspects of supplying industrial gases.

Demand for nitrogen and oxygen in 1986 contrasts with last year's demand, which declined slightly as major consuming industries such as chemicals and steel experienced difficult times. Currently, demand by both these industries, as well as others, is increasing and is expected to continue to do so throughout this year and next. The weakest parts of industrial gas demand in 1986 and later will be in oil production uses, both in enhanced oil recovery and in well stimulation.

Carbon dioxide producers again will have to cope with the problem of limited crude feedstock supply and probably will sell less product than they did last year because of a decline in feedstocks. That problem continues to vary geographically and among producers, and it changes as new sources replace old ones that have declined or ended. Because most carbon dioxide for merchant sale will be recovered from coproduct gas streams of various chemical processes for at least five years, the supply situation also will change as chemical processing changes.

The industrial gases industry is changing in ways other than in sales volume improvement. Great strides have been made in lowering the cost of air separation and storage of liquefied gases, and further efficiencies are expected to develop. Major changes occurred both in delivering the gases to consumers and in how consumers are using the gases in their industries. Pipeline systems in areas of large demand for industrial gases are being expanded. In some areas, new pipeline systems are being planned. Rail and truck delivery of liquefied gases is expanding, as is on-site smaller-scale production through adsorption and membrane technologies. All of these moves result from the need by industrial gas consumers for more service.

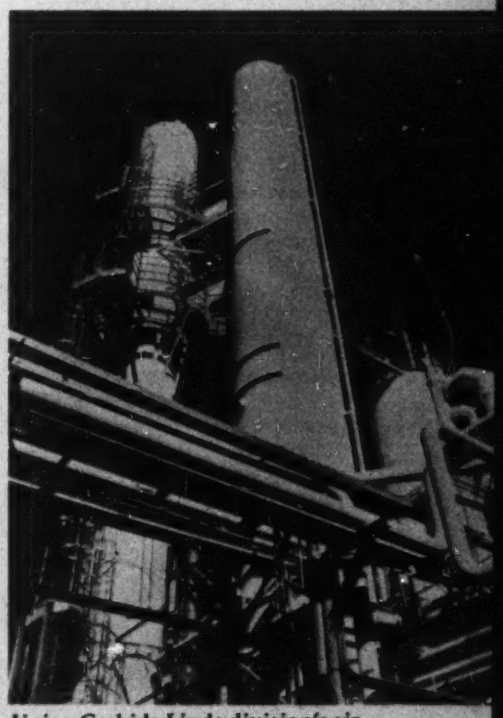
Key Chemicals

The array of delivery systems and use-point storage facilities suggests that the industrial gases business has become more of an equipment and service business than a processing business. Most producers also sell equipment to users of the gases. They instruct consumers in use of the equipment, monitor operations, and develop new equipment, all as part of their services.

Nitrogen sales to the electronics industry is a case in point. Much of the nitrogen sold to or produced on site for the electronics industry meets the "electronics grade"—99.9999% pure. However, as technology and types of components produced by the electronics industry change, demand grows for still higher levels of purity. Also, contamination picked up in piping systems beyond the initial delivery point is pushing companies to pursue a system for final purification at use sites.

Such demands cause industrial gases to be more capital-intensive. They also increase service requirements. Producers will require an ever closer working relationship with consumers to avoid underusing high-cost facilities.

For some details of the near-term outlook for nitrogen, oxygen, and carbon dioxide, please see the following pages.



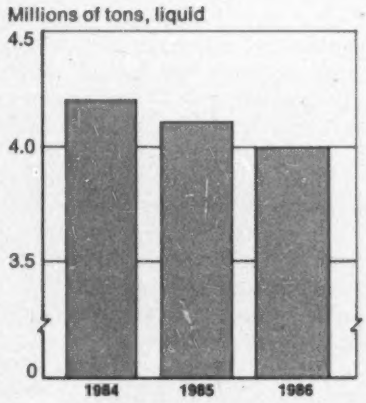
Union Carbide Linde division's air separation plant at Deer Park, Tex.

CO_2

Carbon dioxide

- **Demand strong**
- **Supply tight**
- **Prices improving**

PRODUCTION (nonoilfield)



Note: Excludes CO_2 from natural sources consumed in enhanced oil recovery.

MAJOR PRODUCERS

Amerigas (UGI Corp.), BOC Group, Cardox (division of Liquid Air), Chemetron, Liquid Carbonic

HOW MADE

Recovered from gas streams involved in making ammonia, hydrogen, ethanol by fermentation, and other chemicals, and from natural sources.

MAJOR END USES

Refrigeration 40%, beverage carbonation 20%, chemical manufacture 10%, metals fabrication 10%, enhanced oil recovery 10%

FOREIGN TRADE

Negligible

PRICE

Varies widely with location, averages about $70 per ton

Output of recovered carbon dioxide will decline in 1986, keeping a crimp on sales volume. This year, suppliers to the merchant market are expected to have less carbon dioxide available than they generated last year. Demand for merchant carbon dioxide, however, will absorb nearly all that producers can purify.

The merchant market accounts for a tiny fraction of the total demand for carbon dioxide. Demand for use in enhanced oil recovery (EOR) and in making urea and a few inorganic carbonates is much larger. Other than minor quantities of carbon dioxide purchased for short-term EOR efforts (mostly experimental for the particular geologic formation) all of the carbon dioxide used in EOR comes from underground sources. This natural carbon dioxide is a part of natural gas production and, for some wells, may be the dominant gas. The carbon dioxide is separated from the hydrocarbon and other gases produced from a well, transported by pipeline to the site of an EOR project, then reinjected into a formation to move the oil to a well bore. Frequently, the carbon dioxide produced at one well and used at another remains the property of a single company and never enters the commercial scene. Practically all of the carbon dioxide involved in EOR never becomes reported production.

Similarly, a large fraction of the carbon dioxide coproduced with ammonia will be consumed on site to make urea. Much of this captively consumed carbon dioxide also is not reported production. Estimate of the quantity of carbon dioxide required for urea production in 1986, based on a requirement of 0.75 ton of carbon dioxide per ton of urea, is nearly 5 million tons, if urea output this year totals 6.5 million tons. Both urea and ammonia production is forecast to decline in 1986 because of lower fertilizer demand.

Merchant producers of carbon dioxide will continue to face a difficult supply situation in 1986 because the decline in ammonia production moves with the decline in urea production. Ammonia plants account for about 70% of the merchant carbon dioxide. Lesser quantities are obtained as coproducts of making chemicals (largely ethylene oxide), of making ethanol by fermentation, and of making hydrogen. All of these sources are interruptible because demand for the primary product changes with time. That causes scheduling problems for carbon dioxide sellers.

Even with the supply limitations and high costs of transportation of carbon dioxide in liquid and solid forms, merchant suppliers are developing new markets and expanding existing markets. Some markets are expanding rapidly, and suppliers have to hustle to meet the demand. The two largest markets (refrigeration and carbonation) are propelled by consumer demand following demonstrations of improved technologies. The other uses, mostly industrial, are widely varied and are not growing much.

Nitrogen competes with carbon dioxide in many refrigeration uses. When energy costs rose rapidly, nitrogen lost market share but now may be regaining it, especially with prevailing supply limitations for low-cost carbon dioxide. Because of physical property differences, carbon dioxide has less cooling effect than does the equivalent weight of nitrogen. But the advantage of using nitrogen is offset by other factors, especially by cost at the point of use.

Carbonation also continues to be a growing use of carbon dioxide. Growth in consumption of soft drinks continues to outpace population growth, aided by marketing ploys of the makers. At the same time, the "light beers" are growing very well, requiring increasing amounts of carbonated water for production.

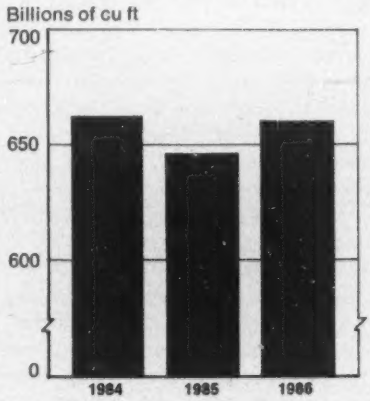
Most other uses of carbon dioxide—welding, inert atmospheres, pressurization, and many others—are growing only slightly.

N_2

Nitrogen

- **Demand to match 1984**
- **Some uses down**
- **Prices competitive**

PRODUCTION



Note: Reported production of gaseous and liquid forms.

MAJOR PRODUCERS

Air Products & Chemicals, BOC Group, Big Three Industries, Liquid Air, Union Carbide's Linde division

HOW MADE

Distillation of liquefied air; pressure swing adsorption using various adsorbents; selective permeability through membranes

MAJOR END USES

Blanketing atmospheres for chemical processing 25%, enhanced oil recovery 25%, electronics manufacture 15%, metals treating and processing 15%, aerospace 5%

FOREIGN TRADE

Negligible

PRICE

50 cents per 100 cu ft

Commercial demand for nitrogen likely will recover this year from last year's slump, but it will not rise much above the 1984 level. Demand in 1986 is expected to be about 660 billion cu ft of nitrogen in both gaseous and liquid forms, excluding most of the nitrogen consumed at ammonia plants.

In 1985, output fell 2%, to a reported production of 647 billion cu ft from the 661 billion cu ft produced in 1984. But the 1984 final estimate was nearly 10% higher than the preliminary estimate. Even so, 1985 production at 647 billion cu ft was down more than 7% from the 700 billion cu ft forecast.

An upturn of nitrogen production to the 1984 level will result from a higher level of chemical manufacturing, some additional use in various metal processing and treating activities, a small gain in use of especially high-purity nitrogen for electronic components manufacturing, and more need for inert gas blanketing in petroleum refineries. The major exception to gains in nitrogen demand will be in the area of enhanced oil recovery (EOR).

Nitrogen in chemical manufacturing (excluding ammonia production) goes largely for blanketing and purging atmospheres. Processes requiring nitrogen blanketing include the drying of chemicals and other products and the blanketing of polymerization reactors. The outlook for this use of nitrogen generally is that it will follow the growth of the chemical industry but with a slightly better rate because of the more sophisticated processing required by the shift toward producing more specialty chemicals.

Use of nitrogen in EOR previously was growing rapidly. Now, with much lower crude oil selling prices, all EOR efforts, and especially those employing nitrogen, are being scrutinized closely for economic justification, and some are being shut down. EOR consumption of nitrogen is higher than has been reported because this area lends itself to captive use by a consumer utilizing a skid-mounted unit to separate nitrogen from air on site. (Coproduct oxygen-enriched air is vented because of the impracticality of moving oxygen a long distance.)

Nitrogen competes with carbon dioxide in EOR. The growth in the pipelines business to carry carbon dioxide from natural production sites to areas of consumption partially reduces demand for nitrogen because of greater availability and lower cost of carbon dioxide. Nitrogen will continue to be used in EOR work, however, because its physical properties are better than those of carbon dioxide for certain production conditions and because combinations of nitrogen and carbon dioxide sometimes provide the best EOR. However, rapid growth in this use of nitrogen is over until crude oil prices return to higher levels. As a result of the change in oil prices, minor growth is all that can be expected for this use of nitrogen in 1986. Its share of consumption with carbon dioxide for EOR also could begin to decline this year.

Blanketing atmospheres for electronic component manufacture has been another fast-growing use of nitrogen. But, in 1985, as a result of competition from imported chips, that use gained very little. Prospects for this year are for the same, with some possibility that consumption could decline even further, depending on electronics product demand and on changes in the technology of making components.

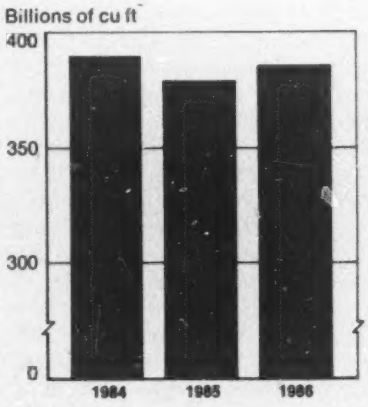
Among other important uses of nitrogen, metals and refrigeration, both significant merchant markets, continue to grow. The reason for the growth in metal processing stems largely from the cost-saving advantages that nitrogen offers. The refrigeration market is buoyed by the general public's seemingly insatiable appetite for fast foods, which require liquid nitrogen for flash freezing. These and other service-oriented merchant markets for liquid nitrogen continue to give merchant producers relatively good profits.

O_2

Oxygen

- *Small demand rise*
- *Capacity holding*
- *Prices steady*

PRODUCTION



Note: Reported production of gaseous and liquid forms.

MAJOR PRODUCERS

Air Products & Chemicals, BOC Group, Big Three Industries, Liquid Air, Union Carbide's Linde division

HOW MADE

Distillation of liquefied air; pressure swing adsorption using various adsorbents

MAJOR END USES

Primary metals manufacture 55%, chemical manufacture 20%, partial oxidation processes 10%, metals fabrication 5%

FOREIGN TRADE

Negligible

PRICE

54 cents per 100 cu ft

Demand for oxygen will remain on hold this year, as it has in the two previous years. A small gain in reported oxygen production in 1986 likely will bring the total back to 385 billion cu ft, in the middle of a 380 billion to 390 billion cu ft range for the annual reported production from 1984 to 1986.

Lack of demand growth for oxygen stems from its use pattern, dominated by production of metals (mostly steel but including some copper). Metals production still takes more than half of oxygen output, most of it tonnage production from on-site or nearby air separation plants. A small additional quantity of oxygen is used in fabrication of metals, again mainly steel, for cutting and welding.

The dominance of metals processing in oxygen consumption, especially steelmaking, had been expected to decline significantly in the early 1980s. Such uses as chemical manufacture and coal gasification were forecast to be growing rapidly by the middle of the decade. Although demand for chemicals based on oxidation processes has expanded about 5% a year, demand for coal gasification uses remains small with little probability of expansion during the rest of the 1980s. The demise of Synthetic Fuels Corp. indicates a bleak future for the near term in use of oxygen to aid gasification of coal.

Most of the small gain in consumption of oxygen in 1986, however, will be by the steel industry. After the extensive rationalization in that industry, the remaining steelmaking furnaces are the most efficient the industry has. These more modern furnaces generally require larger quantities of oxygen per ton of steel produced to gain their better efficiency. Besides consumption of steel tubing and plate by the oil production and refining industries, other demand for steel is forecast to give a small net gain in production over that of 1985.

Chemical uses of oxygen, at about one fifth of total consumption, are dominated by making ethylene oxide, which accounts for about 60% of the total chemical uses. Most, but not all, of the oxygen used in making chemicals is supplied by merchant producers. Purchased oxygen for making chemicals will remain the major source because of the flexibility permitted in plant operations, according to suppliers. Growth in chemical demand for oxygen will be larger than average growth in chemical production because of shifting from air oxidation. However, no major new technologies requiring large quantities of oxygen to make chemicals will become commercial soon.

Most other uses of oxygen are small, each requiring less than 5 to 10% of consumption. None of those uses and no new uses are forecast to grow fast enough to affect total demand significantly. Probably the brightest outlook for increased demand among the small uses belongs to the vast environmental area, dominated by sewage treatment.

Other water treatment processing with oxygen involves wastewater (black liquor) produced at pulp and paper mills and, to a lesser extent, wastewater streams at chemical and other industrial plants. Some of the oxygen required for treating wastewater streams is produced on site, and some is purchased as liquid. If ozone is the oxidant of choice, it may be made on site from purchased liquid oxygen.

Among other uses, a small and growing amount of oxygen is used in pulping processes, primarily aimed at reducing the air and water pollution problems caused by use of inorganic sulfur compounds and chlorine. The space program is another user of oxygen, but demand will be lower this year. Partial oxidation of heavy petroleum fractions to produce just hydrogen for hydrocracking or synthesis gas for chemicals may decline slightly in 1986 because of changes in imports of crude oil and of gasoline. Thus, small uses of oxygen will contribute nothing to growth in demand.

Thermoplastics for engineering will grow

Engineering thermoplastics, already a $1.7 billion business in the U.S., have plenty of growth left in them, at least through 1995. And they will continue to provide a good return on investment of most established producers active in high-margin materials.

However, says Richard M. Kossoff, president of R. M. Kossoff Inc., New York City, competition in engineering thermoplastics is certain to increase, and as it does it will put pressure on profit margins. For most producers, that will mean a lower return on investment, compared with what they had enjoyed in the past.

Kossoff told a recent meeting of the Chemical Marketing Research Association in New York City that, to counter this, engineering thermoplastic suppliers already are drawing up strategies to counter the new competition. Those strategies include ways to cut costs, increase

Nylon to stay highest-volume engineering thermoplastic . . .

Millions of lb	Volume 1985	Volume 1990
Nylon	415	570
Polycarbonate	320	490
Modified polyphenylene oxide[a]	160	230
Polyester[b]	125	220
Acetal	115	155
Polyphenylene sulfide	11	19
Polysulfone	6	8
Higher-performance polymers	3	21

a Also known as polyphenylene ether. b. Comprises polyester terephthalate and polybutylene terephthalate. Source: R. M. Kossoff Inc.

. . . but high-performance grades will grow fastest

Millions of lb	Volume 1985	Volume 1990
Polyacrylate	0.2	5.5
Liquid crystal polymers	0.2	3.0
Polyarylsulfone/polyether ketone	0.1	0.8
Polyetherether ketone	0.1	0.8
Polyetherimide	0.9	7.0
Polyethersulfone	1.3	3.1
Polyamide-imide	0.4	0.6
Other[a]	0.1	0.2
TOTAL	3.3	21.0

a Excludes captive. Source: R. M. Kossoff Inc.

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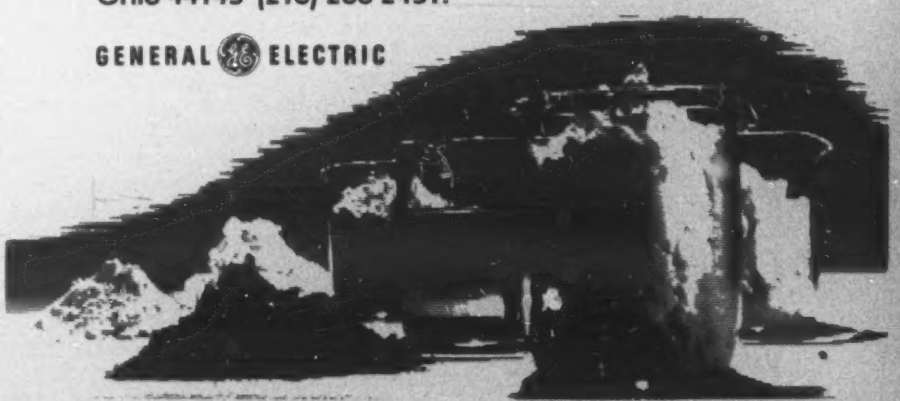
GENERAL ELECTRIC



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SPECIALISTS IN ORGANIC DI-VALENT SULFUR COMPOUNDS

Polythiols-
Polymercaptans
-R-(SH)n

Dimercapto diethyl ether
$O(CH_2CH_2-SH)_2$

Glycol Dimercaptoacetate
$HS-CH_2COOCH_2$
$HS-CH_2COOCH_2$

Glycol Dimercaptopropionate
(Ethylene bis
(b-mercaptopropionate)
$HS-CH_2CH_2COOCH_2$
$HS-CH_2CH_2COOCH_2$

Pentaerythritol Tetra
(3-Mercaptopropionate)
$C(CH_2OOCCH_2CH_2-SH)_4$

Pentaerythritol
Tetrathioglycolate
$C(CH_2OOCCH_2-SH)_4$

Trimethylolethane Tri
(3-Mercaptopropionate)
$CH_3C(CH_2OOCCH_2CH_2-SH)_3$

Trimethylolpropane Tri
(3-Mercaptopropionate)
$CH_3CH_2C(CH_2OOCCH_2CH_2-SH)_3$

Of interest as:
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average prices, and maintain their share of the market, especially in what they consider to be the best end-use segments.

New suppliers, Kossoff says, will have to adopt a "patient money" approach. That's because it usually takes from 10 to 15 years to achieve a positive, cumulative cash flow.

According to Kossoff, consumption of engineering thermoplastics in the U.S. reached 1.2 billion lb last year. Volume could have been higher had it not been for significant imports of finished products, such as cars, business machines, and electronics. Such imports should ease somewhat in 1986 and 1987, he says, as the dollar loses some of its strength, especially against the Japanese yen.

One notable trend has been what Kossoff calls the "explosion" of high-performance alloys, such as polycarbonate/polybutylene terephthalate. He sees volume of those alloys expanding from last year's 230 million lb to 400 million or 500 million lb in 1990. That's a 12 to 17% annual growth rate. Kossoff cautions, however, that although the trend toward alloys has been favorable for the companies that have developed them, it has caused confusion among end users.

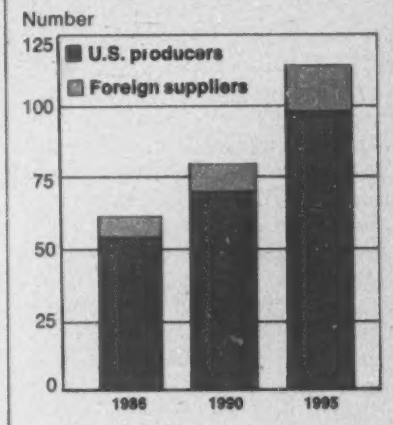
Total consumption of engineering thermoplastics in the U.S. is expected to grow about 8.2% per year through 1990, when volume likely will reach 1.7 billion lb. By then, these plastics may represent a $2.9 billion business. Between 1990 and 1995, Kossoff pegs the average annual growth rate at 9 to 11%, depending upon penetration into the market for exterior auto parts.

The volume leaders among such plastics are nylon and polycarbonate. But in addition to those and other "core" engineering thermoplastics, Kossoff notes that there is a group of high-performance polymers, including high-temperature grades and liquid crystal polymers, that should enjoy a hefty 45%-per-year annual growth rate through 1990.

But, while demand grows in the U.S., the engineering thermoplastics business will become more complex. As patents expire and foreign producers look for larger, faster growth markets, the U.S. becomes an obvious choice for investment, says Kossoff. As a result, the number of U.S. producers will increase, from 53 this year to 98 by 1995. If overseas exporters to the U.S. are included, the number of suppliers will be even higher—perhaps 115 in 1995. The rapid addition of alloys to existing product lines further increases the number of suppliers to the U.S. market.

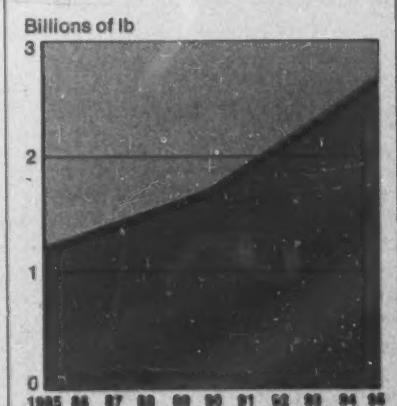
Already, several European companies, such as BASF, Akzo, and Imperial Chemical Industries, have entered the U.S. market via acquisition or by building plants here. Kossoff thinks that foreign firms will continue to acquire reinforced thermoplastics compounders as a means of getting into the U.S. market.

Number of producers and suppliers will increase



Source: R. M. Kossoff Inc.

Engineering thermoplastics to grow moderately



Source: R. M. Kossoff Inc.

So far, Japanese companies have mainly licensed their engineering thermoplastics technology in the U.S. By the 1990s, says Kossoff, at least one or two Japanese companies will start producing in the U.S., either jointly or alone. Some Japanese companies already ship compounded polymers from Japan to Japanese auto parts producers in the U.S. That trend will accelerate, says Kossoff, and will serve as a springboard for Japanese companies to produce the thermoplastics in the U.S.

The expected influx of new producers, as well as the proliferation of new alloys, will put a lot of pressure on profit margins in the 1990s, Kossoff says. Prices of raw materials now are going down, but if they start rising again, producers still will be hard-pressed to increase their prices. That will add to the pressure on profit margins, as will the ability of multimillion-pound customers to bargain for lower prices.

Some existing producers, with depreciated plants and a well-thought-out strategy, will be able to keep margins near (but in most cases, somewhat lower than) existing levels. Kossoff suggests that the return on investment for new capital may drop from the 25- to 35%-range to about 20 to 30% in the 1990s for some companies. New entrants, who will have to spend anywhere from $40 million to $100 million, probably will have to wait 10 or 15 years to achieve a cumulative positive cash flow, he says.

To cope with the lower anticipated profits and the structural changes that lie ahead in engineering thermoplastics, producers are changing their strategies. Some are integrating backward; others are developing multiproduct lines; still others are emphasizing specialties to increase profit margins. Meanwhile, the Pacific Rim will attract attention, because consumption of engineering thermoplastics there is expected to increase from 125 million lb last year to 230 million lb in 1990.

Regardless of the strategy, the critical factors, Kossoff says, will be their ability to cut costs, raise average selling prices, and maintain or increase market share. □

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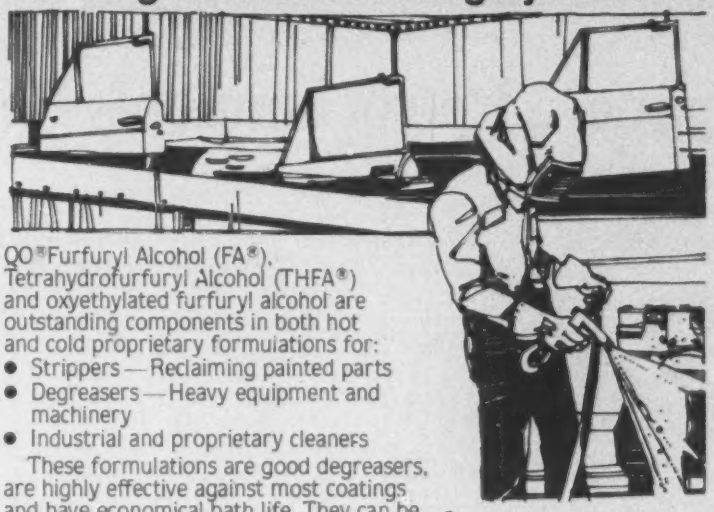

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ACS Committee on Professional Training 1985 Annual Report

The number of bachelor's degree graduates in chemistry from colleges and universities whose undergraduate chemistry programs are approved by the American Chemical Society decreased 1.5% in the 1984–85 academic year from the previous year. The number of master's degrees from these departments dropped less than 1%, and the number of Ph.D. degrees continued to rise for the sixth year in a row, this year 1.5%. These departments project increases for 1986 of 6% for bachelor's degrees, and 20% for both master's and Ph.D. degrees. (It should be noted, however, that these projections are usually higher than actual counts a year later.)

The percentage of baccalaureate graduates certified to ACS was 42%, down slightly from 43% last year. (Certified graduates are those who have completed the curriculum specified by the Committee on Professional Training and are eligible for full membership in ACS; noncertified graduates may become associate members of ACS upon graduation and full members after three years of professional experience or a higher degree in a chemical science.)

A total of 2463 of the bachelor's degree graduates from the approved schools were reported as planning to go to graduate school, and 2052 reported plans to go to professional schools.

Total numbers of bachelor's degrees (certified and noncertified), master's degrees, and Ph.D. degrees awarded in 1984–85 by departments whose chemistry programs are ACS approved are listed by institution in the large table at the end of this report and are summarized in the two smaller tables. These tables also include numbers of chemical engineering graduates from institutions whose programs are accredited by the American Institute of Chemical Engineers and the Accreditation Board for Engineering & Technology. (Note: These departments are not required to report their data to CPT, so the number of departments included varies each year.) Also included is a table with information on graduate student enrollments in chemistry departments whose undergraduate programs are approved by the society.

The number of bachelor's degrees in chemical engineering from the 123 AIChE-ABET-accredited departments that reported in 1985 decreased 6% from the total reported by 120 departments in 1984, the second decrease in a row. These 123 departments reported an expected further decrease in bachelor's degrees of 14% in 1986. At the graduate level, the number of chemical engineering master's and Ph.D. degrees increased for the sixth year in a row. The number of master's degrees was up 3.6% from 1984, and the number of Ph.D.s was up 17%. Projected 1986 numbers of master's and Ph.D. degrees in chemical engineering from these schools are down less than 1% for master's degrees and up 44% for Ph.D.s.

The chemistry programs at ACS-approved schools normally are reevaluated at five-year intervals. There were 579 colleges and universities on the approved list at the end of 1985. During the year the committee studied the chemistry programs of 163 of the approved schools and of 11 schools applying

Summary of totals from 1985 reports from approved schools

	Schools reporting	Men	Women	Total
CHEMISTRY				
Bachelors, total	579	6263	3416	9679
Certified		2604	1417	4021
Noncertified		3659	1999	5658
Masters	316	1097	524	1621
Doctorates	186	1447	359	1806
CHEMICAL ENGINEERING				
Bachelors, certified	123	4797	1645	6442
Masters	118	1234	255	1489
Doctorates	104	383	35	418

Summary of data from approved schools, 1981–85

	Bachelors				Masters		Doctorates	
	Number of schools	Graduates (totals)	Certified graduates	Noncertified graduates	Number of schools	Graduates	Number of schools	Graduates
CHEMISTRY								
1981	558	10,453	4337	6116	323	1609	187	1613
1982	561	9,866	4179	5687	322	1645	187	1683
1983	570	10,043	4233	5810	320	1569	189	1759
1984	577	9,819	4201	5618	321	1637	189	1777
1985	579	9,679	4021	5658	316	1621	186	1806
CHEMICAL ENGINEERING[a]								
1981	110	5,831	5831	—	106	1020	87	250
1982	113	5,963	5963	—	109	1171	92	293
1983	122	7,021	7021	—	116	1317	101	333
1984	120	6,866	6866	—	114	1436	101	357
1985	123	6,442	6442	—	118	1489	104	418

a Chemical engineering departments are not required to report their data to CPT, so the number of departments included in this category varies from year to year.

Committee members, 1985

Henry A. Bent, *chairman*
North Carolina State University
Robert C. Brasted
University of Minnesota
Marjorie C. Caserio
University of California, Irvine
Alice J. Cunningham
Agnes Scott College
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AT&T Bell Laboratories
Ernest L. Eliel, *consultant*
University of North Carolina, Chapel Hill
Harry B. Gray, *consultant*
California Institute of Technology
Bonnie R. Blaser, *committee secretary* to Aug. 1, 1985
Barbara A. Gallagher, *committee secretary* after Aug. 1, 1985
Cathy A. Nelson, *staff associate*
Dolphine S. Hite, *program assistant*
American Chemical Society

for ACS approval. Each evaluation involved a review of extensive documentary materials submitted by the department chair describing the current status of the program.

No schools were added to the ACS-approved list by the ACS Committee on Professional Training in 1985; one was put on probation; one was removed from probation; six continued on probation; and one was removed from the list.

Two issues of the CPT Newsletter were published in 1985. Distribution for each issue was approximately 12,000 college chemistry faculty members. Topics ranged from the importance of *CA* subscriptions in colleges to speaking and writing skills for students to a description of the CPT review process to provocative opinions and trends in chemical education. The second issue of the newsletter demonstrated its effectiveness as a vehicle for information exchange through a lively "Letters" column.

A Committee on Professional Training task force that met with representatives of the American Society of Biological Chemists developed a proposal for an ACS-approved chemistry degree with a biochemistry emphasis. After developing a tentative course of study and exploring the potential interest among chemistry students, CPT decided to present its proposal to the ACS Board of Directors at the April 1986 meeting.

A new edition of the ACS Directory of Graduate Research was published in November 1985. This edition contains 713 academic departments, 11,215 faculty members, and 58,760 publication citations. The DGR-Online, a computerized database of all the information in the printed version, also was updated. Special features of the on-line database that are not available in the printed version include data on faculty gender and controlled vocabulary for searching specific chemical research interests. The database is available through BRS Information Technologies. Further information on the file may be obtained from Cathy A. Nelson, ACS Office of Professional Training, 1155—16th St., N.W., Washington, D.C. 20036, telephone (202) 872-4599.

The committee continued its series of visits by two-person committee teams to constituent institutions. The purpose of these visits is for CPT members to learn more about current trends in chemistry education and about how the CPT Guidelines fit with these trends. The committee will evaluate this project after the final three scheduled visits have been completed in 1986.

Other CPT activities in 1985 included formation of a subcommittee to interact with the ACS Society Committee on Education Task Force on ACS Involvement in the Two-Year Colleges; survey of interest in a conference to address the concerns of small colleges on the ACS-approved list; initiation of a questionnaire to gather information on science/chemistry building construction; participation in an electronic mail experiment; and continuation of a project to computerize all data received from ACS-approved schools.

The committee would like to acknowledge and thank the following visiting associates of the committee who conducted on-site visits to schools on the approved list or applying for ACS approval during 1985: Ivan Bernal, University of Houston; Larry K. Blair, Berea College; J. Nicholas Burnett, Davidson College; Charles P. Casey, University of Wisconsin; John W. Coutts, Lake Forest College; John P. Fackler Jr., Texas A&M University; Donald E. Jones, Western Maryland College; Jerry R. Mohrig, Carleton College; David L. Powell, College of Wooster.

Graduate student enrollments in departments whose undergraduate chemistry programs are ACS approved

	Number of departments	First-year graduate students		All graduate students	
		Full time	Part time	Full time	Part time
M.S. DEPARTMENTS[a]					
Fall 1982	131	494	310	1,075	1048
Fall 1983	132	452	293	1,098	981
Fall 1984	131	468	270	1,099	990
PH.D. DEPARTMENTS					
Fall 1982	189	3412	306	13,488	1483
Fall 1983	189	3554	275	14,037	1380
Fall 1984	186	3404	227	14,194	1314

a Departments whose highest offering is the master's degree in chemistry.

Chemistry and chemical engineering degrees awarded by approved schools, 1984–85

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Abilene Christian U	6	8	1	—	—	—	—
Adelphi U	3	6	2	—	—	—	—
Agnes Scott C	2	3	—	—	—	—	—
Akron, U of	16	2	5	4	a	—	—
Alabama, U of							
University	1	10	4	4	46	8	1
Birmingham	3	3	2	0	—	—	—
Huntsville	2	7	6	—	—	—	—
Alaska, U of	4	1	1	—	—	—	—
Albion C	1	11	—	—	—	—	—
Albright C	5	21	—	—	—	—	—
Alfred U	5	0	—	—	—	—	—
Allegheny C	1	17	—	—	—	—	—
Alma C	3	7	—	—	—	—	—
American U	5	3	4	11	—	—	—
Amherst C	0	13	—	—	—	—	—
Andrews U	5	8	—	—	—	—	—
Appalachian State U	3	6	0	—	—	—	—
Arizona State U	21	20	3	12	41	15	0
Arizona, U of	16	27	2	16	22	13	3
Arkansas, U of							
Fayetteville	3	7	1	5	46	14	4
Little Rock	2	5	2	—	—	—	—
Ashland C	2	1	—	—	—	—	—
Auburn U	4	28	8	2	75	9	1
Augsburg C	3	1	—	—	—	—	—
Augustana C (Illinois)	0	23	—	—	—	—	—
Augustana C (South Dakota)	2	4	—	—	—	—	—
Austin C	1	10	—	—	—	—	—
Baldwin-Wallace C	0	5	—	—	—	—	—
Ball State U	1	4	4	—	—	—	—
Barnard C	1	8	—	—	—	—	—
Bates C	4	10	—	—	—	—	—
Baylor U	4	11	0	2	—	—	—
Beloit C	3	9	—	—	—	—	—
Bemidji State U	2	9	—	—	—	—	—
Birmingham-Southern C	4	12	—	—	—	—	—
Bloomsburg U	4	0	—	—	—	—	—
Boston C	27	0	6	3	—	—	—
Boston U	1	16	4	6	—	—	—
Bowdoin C	1	27	—	—	—	—	—
Bowling Green State U	7	20	6	—	—	—	—
Bradley U	1	8	—	—	—	—	—
Brandeis U	0	13	9	5	—	—	—
Bridgeport, U of	4	1	0	—	—	—	—
Bridgewater State C	3	5	0	—	—	—	—
Brigham Young U	8	26	6	6	63	11	1
Brown U	0	14	0	16	—	—	—
Bryn Mawr C	15	0	1	1	—	—	—
Bucknell U	10	10	2	—	36	2	—
Butler U	5	15	7	—	—	—	—
California Institute of Tech	11	0	0	24	8	13	11
California Polytechnic State U	20	50	4	—	—	—	—
California State C							
Bakersfield	4	4	—	—	—	—	—
Stanislaus	1	5	—	—	—	—	—
California State Polytechnic U	5	4	3	—	a	—	—
California State U							
Chico	1	12	—	—	—	—	—
Dominguez Hills	4	6	—	—	—	—	—
Fresno	4	8	3	—	—	—	—
Fullerton	16	12	4	—	—	—	—
Hayward	6	13	1	—	—	—	—
Long Beach	8	16	4	—	75	—	—
Los Angeles	14	2	3	—	—	—	—
Northridge	12	7	3	—	—	—	—
Sacramento	9	10	5	—	—	—	—
San Bernardino	2	9	—	—	—	—	—
California, U of							
Berkeley	49	1	9	68	98	12	17
Davis	25	7	6	22	44	13	2
Irvine	10	46	6	13	—	—	—
Los Angeles	29	68	17	37	19	13	3
Riverside	7	3	4	13	—	—	—
San Diego	63	0	20	15	—	—	—
Santa Barbara	23	11	8	17	36	6	3
Santa Cruz	19	8	11	4	—	—	—
Calvin C	1	6	—	—	—	—	—
Canisius C	10	6	—	—	—	—	—
Capital U	1	5	—	—	—	—	—
Carleton C	2	33	—	—	—	—	—
Carnegie-Mellon U	26	0	7	4	57	9	13
Carroll C	5	9	—	—	—	—	—
Carthage C	3	2	—	—	—	—	—
Case Western Reserve U	4	33	7	12	51	11	3
Catholic U of America	0	0	1	3	a	—	—
Centenary C of Louisiana	0	0	—	—	—	—	—
Central C	0	5	—	—	—	—	—
Central Connecticut State U	4	1	0	—	—	—	—
Central Florida, U of	18	0	6	—	—	—	—
Central Michigan U	3	20	8	—	—	—	—
Central State U (Ohio)	0	3	—	—	—	—	—
Central State U (Oklahoma)	2	10	—	—	—	—	—
Centre C	0	1	—	—	—	—	—
Charleston, C of	12	10	—	—	—	—	—
Chatham C	0	4	—	—	—	—	—
Chestnut Hill C	6	5	—	—	—	—	—
Chicago, U of	9	30	4	16	—	—	—
Cincinnati, U of	30	0	13	24	64	10	1
Citadel, The	2	3	—	—	—	—	—
City U of New York							
Graduate Center	—	—	—	13	—	—	—
Brooklyn C	2	20	3	—	—	—	—
City C	5	15	1	—	39	8	3
Herbert H. Lehman C	4	9	—	—	—	—	—
Hunter C	4	6	—	—	—	—	—
Queens C	4	22	9	0	—	—	—
Clarion U of Pennsylvania	5	0	—	—	—	—	—
Clark U	6	0	0	0	—	—	—
Clarkson U	14	0	6	2	110	16	5
Clemson U	5	1	6	6	65	8	2
Cleveland State U	16	0	9	6	30	9	2
Coe C	0	5	—	—	—	—	—
Colby C	2	5	—	—	—	—	—
Colgate U	0	24	—	—	—	—	—
Colorado C	4	6	—	—	—	—	—
Colorado School of Mines	7	0	2	3	94	12	0
Colorado State U	8	5	3	16	32	7	0
Colorado, U of							
Boulder	13	40	8	17	65	15	4
Colorado Springs	5	6	—	—	—	—	—
Denver	4	9	0	—	—	—	—
Columbia U	6	6	26	18	44	29	6
Concordia C	4	2	—	—	—	—	—
Connecticut, U of	23	11	5	6	50	13	1
Cooper Union[b]	—	—	—	—	a	—	—
Cornell C	0	5	—	—	—	—	—
Cornell U	20	27	31	18	a	—	—
Creighton U	0	31	2	—	—	—	—
Dartmouth C	0	18	0	5	—	—	—
David Lipscomb C	1	11	—	—	—	—	—
Davidson C	5	2	—	—	—	—	—
Dayton, U of	9	9	1	—	42	7	—
Delaware State C	0	2	—	—	—	—	—
Delaware, U of	39	16	4	12	62	18	8
Delaware Valley C of Science & Agriculture	8	0	—	—	—	—	—
Delta State U	4	5	—	—	—	—	—
Denison U	1	6	—	—	—	—	—
Denver, U of	2	23	6	0	—	—	—
De Paul U	3	2	6	—	—	—	—
DePauw U	6	13	—	—	—	—	—
Detroit, U of	6	3	10	0	12	14	—
Dickinson C	1	15	—	—	—	—	—
Drake U	2	5	—	—	—	—	—
Drew U	1	10	—	—	—	—	—
Drexel U	10	0	14	3	78	12	1
Duke U	19	33	1	14	—	—	—
Duquesne U	1	4	1	1	—	—	—
Earlham C	3	7	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
East Carolina U	6	2	4	—	—	—	—
East Stroudsburg U	5	4	0	—	—	—	—
East Tennessee State U	4	9	1	—	—	—	—
East Texas State U	2	4	2	—	—	—	—
Eastern Illinois U	4	6	2	—	—	—	—
Eastern Kentucky U	6	16	3	—	—	—	—
Eastern Michigan U	4	37	6	—	—	—	—
Eastern New Mexico U	0	2	4	—	—	—	—
Eckerd C	4	1	—	—	—	—	—
Elizabethtown C	3	12	—	—	—	—	—
Elmhurst C	1	18	—	—	—	—	—
Emory U	1	82	4	13	—	—	—
Emporia State U	2	3	1	—	—	—	—
Evansville, U of	2	2	—	—	—	—	—
Fairfield U	7	1	—	—	—	—	—
Fairleigh Dickinson U							
Madison	7	0	3	—	—	—	—
Teaneck	19	1	6	—	—	—	—
Fisk U	10	0	1	—	—	—	—
Florida Atlantic U	9	16	—	—	—	—	—
Florida Institute of Tech	1	1	2	—	13	0	—
Florida International U	4	11	—	—	—	—	—
Florida State U	1	24	6	13	—	—	—
Florida, U of	8	41	7	20	59	21	10
Fordham U	0	17	2	—	—	—	—
Fort Lewis C	3	11	—	—	—	—	—
Franklin & Marshall C	10	12	—	—	—	—	—
Furman U	12	3	2	—	—	—	—
Geneva C	1	16	—	—	—	—	—
George Mason U	9	4	—	—	—	—	—
George Washington U	9	10	2	1	—	—	—
Georgetown U	21	0	3	4	—	—	—
Georgia Institute of Tech	15	0	4	13	165	20	2
Georgia State U	2	2	2	—	—	—	—
Georgia, U of	6	39	10	16	—	—	—
Gettysburg C	2	9	—	—	—	—	—
Glassboro State C	7	2	—	—	—	—	—
Gonzaga U	3	3	—	—	—	—	—
Goucher C	1	8	—	—	—	—	—
Grand Valley State C	1	10	—	—	—	—	—
Grinnell C	5	15	—	—	—	—	—
Gustavus Adolphus C	2	10	—	—	—	—	—
Hamilton C	0	5	—	—	—	—	—
Hamline U	9	2	—	—	—	—	—
Hampden-Sydney C	2	5	—	—	—	—	—
Hampton U	6	1	2	—	—	—	—
Hartford, U of	3	3	0	—	—	—	—
Hartwick C	4	5	—	—	—	—	—
Harvard U	0	24	11	20	—	—	—
Harvey Mudd C	16	0	—	—	—	—	—
Haverford C	1	7	—	—	—	—	—
Hawaii, U of	15	5	2	9	—	—	—
Hiram C	4	5	—	—	—	—	—
Hobart & William Smith C	1	4	—	—	—	—	—
Hofstra U	2	15	—	—	—	—	—
Hollins C	0	2	—	—	—	—	—
Holy Cross, C of the	22	12	—	—	—	—	—
Hope C	22	16	—	—	—	—	—
Houston, U of	17	2	10	15	40	35	6
Howard U	2	32	9	5	15	1	—
Humboldt State U	1	5	—	—	—	—	—
Idaho State U	2	4	0	—	—	—	—
Idaho, U of	5	4	2	3	21	8	2
Illinois Benedictine C	15	0	—	—	—	—	—
Illinois Institute of Tech	2	0	4	3	44	17	4
Illinois State U	31	0	11	—	—	—	—
Illinois, U of							
Chicago	19	19	19	9	40	18	0
Urbana-Champaign	63	39	12	56	98	20	22
Illinois Wesleyan U	3	3	—	—	—	—	—
Indiana State U	7	0	2	—	—	—	—
Indiana U							
Bloomington	29	120	11	26	—	—	—
South Bend	2	1	—	—	—	—	—
Indiana U of Pennsylvania	13	5	7	—	—	—	—
Indiana U-Purdue U							
Fort Wayne	6	6	—	—	—	—	—
Indianapolis	2	20	8	—	—	—	—
Iowa State U	11	6	4	35	73	12	5
Iowa, U of	14	0	10	7	32	8	2
Ithaca C	5	7	—	—	—	—	—
Jackson State U	2	3	7	—	—	—	—
James Madison U	4	3	—	—	—	—	—
John Carroll C	4	15	0	—	—	—	—
Johns Hopkins U	24	0	9	9	14	4	0
Juniata C	2	13	—	—	—	—	—
Kalamazoo C	5	23	—	—	—	—	—
Kansas State U	6	5	7	9	28	5	2
Kansas, U of	20	29	4	8	32	11	1
Kean C of New Jersey	5	9	—	—	—	—	—
Kearney State C	2	5	—	—	—	—	—
Kent State U	11	9	1	3	—	—	—
Kentucky, U of	14	16	7	4	60	6	2
Kenyon C	5	4	—	—	—	—	—
King's C	3	3	—	—	—	—	—
Knox C	2	14	—	—	—	—	—
Lafayette C	4	13	—	—	37	—	—
Lake Forest C	0	9	—	—	—	—	—
Lamar U	9	2	0	—	26	19	3
La Salle C	4	2	—	—	—	—	—
Lawrence Institute of Tech	7	0	—	—	—	—	—
Lawrence U[c]	4	2	14	3	—	—	—
Lebanon Valley C	5	8	—	—	—	—	—
Lehigh U	8	0	12	12	66	37	3
Le Moyne C	4	2	—	—	—	—	—
Lincoln U	1	13	—	—	—	—	—
Long Island U							
Brooklyn Center	0	12	9	—	—	—	—
C. W. Post Campus	1	1	—	—	—	—	—
Loras C	0	2	—	—	—	—	—
Louisiana State U							
Baton Rouge	10	3	0	12	51	14	2
Shreveport	3	0	—	—	—	—	—
Louisiana Tech U	3	4	3	—	18	5	1
Louisville, U of	7	24	1	5	28	14	0
Lowell, U of	11	0	2	5	a	—	—
Loyola C	11	1	—	—	—	—	—
Loyola Marymount U	5	0	—	—	—	—	—
Loyola U (New Orleans)	1	1	—	—	—	—	—
Loyola U (Chicago)	18	9	6	5	—	—	—
Luther C	4	5	—	—	—	—	—
Macalester C	2	8	—	—	—	—	—
Maine, U of	5	3	4	0	48	6	3
Manhattan C[d]	11	3	—	—	67	35	—
Manhattanville C	2	1	—	—	—	—	—
Mankato State U	6	9	0	—	—	—	—
Marietta C	1	0	—	—	—	—	—
Marist C	0	1	—	—	—	—	—
Marquette U	14	0	1	4	—	—	—
Marshall U	3	17	1	—	—	—	—
Maryland, U of							
College Park	22	52	13	22	84	10	6
Baltimore County	14	0	4	—	—	—	—
Massachusetts Institute of Tech	25	0	1	39	102	55	27
Massachusetts, U of	8	10	8	17	46	10	14
McMurry C	0	2	—	—	—	—	—
McNeese State U	4	3	2	—	—	—	—
Memphis State U	2	6	0	0	—	—	—
Mercer U	7	3	—	—	—	—	—
Merrimack C	8	1	—	—	—	—	—
Metropolitan State C	7	8	—	—	—	—	—
Miami U	16	37	5	4	—	—	—
Miami, U of	3	96	0	1	—	—	—
Michigan State U	31	21	4	17	75	15	0
Michigan Technological U	20	0	1	3	81	5	0
Michigan, U of							
Ann Arbor	62	0	31	24	116	21	12
Dearborn	6	17	—	—	—	—	—
Flint	3	6	—	—	—	—	—
Middle Tennessee State U	0	21	4	—	—	—	—
Middlebury C	0	12	0	—	—	—	—
Midwestern State U	4	4	—	—	—	—	—
Millersville U	5	11	—	—	—	—	—
Millsaps C	1	21	—	—	—	—	—
Minnesota, U of							
Minneapolis	41	0	14	26	a	—	—
Duluth	9	12	5	—	—	—	—
Mississippi C	0	8	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Mississippi State U	1	2	3	4	59	5	0
Mississippi, U of	1	11	2	0	18	10	1
Missouri, U of							
Columbia	20	7	5	3	58	6	1
Kansas City	3	16	0	3	—	—	—
Rolla	10	0	5	5	109	10	1
St. Louis	10	11	4	2	—	—	—
Missouri Western State C	3	0	—	—	—	—	—
Monmouth C (Illinois)	0	7	—	—	—	—	—
Monmouth C (New Jersey)	3	0	—	—	—	—	—
Montana C of Mineral Science & Tech	3	1	2	—	—	—	—
Montana State U	3	6	4	5	80	6	0
Montana, U of	8	4	1	2	—	—	—
Montclair State C	1	14	8	—	—	—	—
Moorhead State U	2	5	—	—	—	—	—
Moravian C	3	2	—	—	—	—	—
Morehouse C[a]	0	5	7	2	—	—	—
Morgan State U	3	7	—	—	—	—	—
Mount Holyoke C	0	15	1	0	—	—	—
Mount Saint Vincent, C of[d]	0	1	—	—	—	—	—
Muhlenberg C	0	21	—	—	—	—	—
Murray State U	6	17	2	—	—	—	—
Muskingum C	1	2	—	—	—	—	—
Nebraska, U of							
Lincoln	0	15	3	8	21	10	0
Omaha	3	2	—	—	—	—	—
Nebraska Wesleyan U	3	4	—	—	—	—	—
Nevada, U of							
Las Vegas	1	3	—	—	—	—	—
Reno	2	0	1	1	—	—	—
New Hampshire, U of	10	9	4	6	25	8	1
New Jersey Institute of Tech[b]	—	—	—	—	81	21	5
New Mexico Highlands U	0	1	2	—	—	—	—
New Mexico Institute of Mining & Tech	12	0	2	—	—	—	—
New Mexico State U	6	11	4	8	21	7	—
New Mexico, U of	7	9	10	7	25	18	7
New Orleans, U of	1	7	1	4	—	—	—
New York U	8	48	14	11	—	—	—
Niagara U	2	9	—	—	—	—	—
North Alabama, U of	3	8	—	—	—	—	—
North Carolina A&T State U	1	0	3	—	—	—	—
North Carolina Central U	1	10	1	—	—	—	—
North Carolina State U	18	20	2	6	123	11	4
North Carolina, U of							
Asheville	4	2	—	—	—	—	—
Chapel Hill	34	80	5	22	—	—	—
Charlotte	3	6	1	—	—	—	—
Greensboro	5	5	4	—	—	—	—
Wilmington	4	8	—	—	—	—	—
North Dakota State U	0	21	4	1	—	—	—
North Dakota, U of	2	8	1	0	25	4	—
North Texas State U	4	8	7	8	—	—	—
Northeast Louisiana U	2	2	7	—	—	—	—
Northeastern Illinois U	0	8	3	—	—	—	—
Northeastern U	4	0	11	8	52	10	0
Northern Arizona U	6	19	0	—	—	—	—
Northern Colorado, U of	0	7	0	0	—	—	—
Northern Illinois U	12	9	5	3	—	—	—
Northern Iowa, U of	6	17	2	—	—	—	—
Northern Kentucky U	3	6	—	—	—	—	—
Northern Michigan U	0	5	0	—	—	—	—
Northwest Missouri State U	5	1	—	—	—	—	—
Northwestern State U of Louisiana	0	1	—	—	—	—	—
Northwestern U	20	15	16	22	a	—	—
Norwich U	0	0	—	—	—	—	—
Notre Dame, U of	8	11	6	7	65	12	10
Oakland U	1	1	2	—	—	—	—
Oberlin C	0	22	—	—	—	—	—
Occidental C	1	5	—	—	—	—	—
Ohio Northern U	4	5	—	—	—	—	—
Ohio State U	36	0	18	34	75	27	2
Ohio U	13	4	5	1	22	8	0
Ohio Wesleyan U	0	5	—	—	—	—	—
Oklahoma State U	2	4	1	6	40	22	6
Oklahoma, U of	10	26	16	6	33	21	3
Old Dominion U	7	2	9	—	—	—	—
Oregon State U	12	0	5	6	47	9	1
Oregon, U of	7	29	5	7	—	—	—
Pace U	1	3	—	—	—	—	—
Pacific Lutheran U	2	5	—	—	—	—	—
Pacific, U of the	2	7	3	0	—	—	—
Pennsylvania State U	5	37	5	31	164	16	3
Pennsylvania, U of	4	20	5	26	35	6	5
Philadelphia C of Pharmacy & Science	10	0	2	0	—	—	—
Philadelphia C of Textiles & Science	7	0	—	—	—	—	—
Pittsburg State U	7	2	3	—	—	—	—
Pittsburgh, U of	14	69	9	18	87	29	3
Polytechnic Institute of N.Y.	5	6	9	7	31	12	2
Pomona C	5	7	—	—	—	—	—
Portland State U	0	9	1	1	—	—	—
Pratt Institute[b]	—	—	—	—	7	—	—
Princeton U	27	9	14	20	33	3	14
Providence U	5	4	0	0	—	—	—
Puerto Rico, U of							
Mayaguez	27	1	7	—	77	5	—
Rio Piedras	20	53	5	6	—	—	—
Puget Sound, U of	4	5	—	—	—	—	—
Purdue U	30	22	14	46	148	14	10
Purdue U Calumet	5	2	—	—	—	—	—
Randolph-Macon Woman's C	3	1	—	—	—	—	—
Redlands, U of	1	1	—	—	—	—	—
Reed C	14	6	—	—	—	—	—
Regis C	0	1	—	—	—	—	—
Rensselaer Polytechnic Inst	20	0	25	14	73	14	1
Rhode Island, U of	5	1	2	3	a	—	—
Rhodes C	7	8	—	—	—	—	—
Rice U	17	1	8	7	26	4	8
Richmond, U of	0	16	1	—	—	—	—
Rider C	4	0	—	—	—	—	—
Ripon C	5	1	—	—	—	—	—
Roanoke C	2	9	—	—	—	—	—
Rochester Institute of Tech	16	5	6	—	—	—	—
Rochester, U of	15	0	25	15	52	22	2
Rollins C	4	1	—	—	—	—	—
Roosevelt U	7	5	7	—	—	—	—
Rose-Hulman Institute of Tech	6	0	—	—	a	—	—
Russell Sage C	4	0	—	—	—	—	—
Rutgers U							
New Brunswick	51	17	10	12	77	26	7
Camden C	0	10	—	—	—	—	—
Newark C of Arts & Sciences	10	15	14	2	—	—	—
Saginaw Valley State C	3	8	—	—	—	—	—
St. Anselm C	3	4	—	—	—	—	—
St. Catherine, C of	1	6	—	—	—	—	—
St. Cloud State U	1	11	—	—	—	—	—
St. John Fisher C	10	6	—	—	—	—	—
St. John's U	7	2	8	—	—	—	—
St. John's U/C of St. Benedict	6	11	—	—	—	—	—
St. Joseph C	2	5	6	—	—	—	—
St. Joseph's U	5	25	7	—	—	—	—
St. Lawrence U	3	18	—	—	—	—	—
St. Louis U	7	30	10	—	—	—	—
St. Mary's C	2	5	—	—	—	—	—
St. Michael's C	4	0	—	—	—	—	—
St. Olaf C	6	46	—	—	—	—	—
St. Peter's C	4	5	—	—	—	—	—
St. Thomas, C of	0	8	—	—	—	—	—
Salem State C	4	0	—	—	—	—	—
Sam Houston State U	6	2	5	—	—	—	—
San Diego State U	19	2	6	1	—	—	—
San Francisco State U	11	23	6	—	—	—	—
San Francisco, U of	2	6	4	—	—	—	—
San Jose State U	26	11	12	—	20	10	—
Sangamon State U	1	2	—	—	—	—	—
Santa Clara, U of	4	4	—	—	—	—	—
Scranton, U of	6	23	15	—	—	—	—
Seattle U	2	4	—	—	—	—	—
Seton Hall U	5	7	10	11	—	—	—
Shippensburg U	11	1	2	—	—	—	—
Siena C	11	0	—	—	—	—	—
Simmons C	1	1	—	—	—	—	—
Skidmore C	2	15	—	—	—	—	—
Smith C	13	0	0	0	—	—	—
Sonoma State U	3	19	—	—	—	—	—
South Carolina, U of	0	20	8	23	28	5	0

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
South Dakota School of Mines & Tech	5	0	5	—	36	6	—
South Dakota State U	4	20	4	—	—	—	—
South Dakota, U of	8	11	4	—	—	—	—
South Florida, U of	23	52	1	3	45	2	0
Southeast Missouri State U	2	6	—	—	—	—	—
Southeastern Louisiana U	0	2	—	—	—	—	—
Southeastern Massachusetts U	12	3	1	—	—	—	—
Southern California, U of	15	8	3	13	46	11	1
Southern Colorado U	1	9	—	—	—	—	—
Southern Illinois U							
Carbondale	7	8	2	9	—	—	—
Edwardsville	6	4	8	—	—	—	—
Southern Methodist U	4	3	1	—	—	—	—
Southern Mississippi, U of	2	17	3	2	—	—	—
Southern Oregon State C	7	1	—	—	—	—	—
Southern U & A&M C	2	2	1	—	—	—	—
Southwest Missouri State U	1	16	—	—	—	—	—
Southwest State U	3	5	—	—	—	—	—
Southwest Texas State U	11	3	8	—	—	—	—
Southwestern Louisiana, U of	0	6	2	—	a	—	—
Southwestern Oklahoma State U	4	6	—	—	—	—	—
Stanford U	9	7	3	19	14	26	9
State U of New York							
Albany	21	1	2	4	—	—	—
Binghamton	7	25	7	5	—	—	—
Buffalo	20	17	8	13	99	18	5
Stony Brook	25	31	3	17	—	—	—
C at Brockport	6	6	—	—	—	—	—
C at Buffalo	6	4	2	—	—	—	—
C at Cortland	3	6	—	—	—	—	—
C at Fredonia	9	10	1	—	—	—	—
C at Geneseo	8	0	0	—	—	—	—
C at New Paltz	8	1	0	—	—	—	—
C at Oneonta	1	20	0	—	—	—	—
C at Oswego	14	8	5	—	—	—	—
C at Plattsburgh	10	10	1	—	—	—	—
C at Potsdam	0	19	—	—	—	—	—
Stephen F. Austin State U	2	4	1	—			
Stetson U	5	4	—	—	—	—	—
Stevens Institute of Tech	5	4	8	1	—	—	—
Suffolk U	2	2	—	—	—	—	—
Susquehanna U	3	2	—	—	—	—	—
Swarthmore C	7	10	—	—	—	—	—
Syracuse U	10	7	0	4	20	14	0
Temple U	8	12	1	7	—	—	—
Tennessee Technological U	3	12	1	—	35	6	0
Tennessee, U of							
Knoxville	4	16	2	8	91	13	5
Martin	3	7	—	—	—	—	—
Chattanooga	16	13	—	—	—	—	—
Texas A&I U	3	0	3	—	13	4	—
Texas A&M U	22	9	11	22	123	23	3
Texas Christian U	3	13	2	2	—	—	—
Texas Southern U	10	0	6	—	—	—	—
Texas Technological U	12	16	9	4	42	10	3
Texas, U of							
Arlington	12	6	4	0	—	—	—
Austin	42	0	8	28	115	26	17
Dallas	8	1	9	—	—	—	—
El Paso	8	0	8	—	—	—	—
Texas Woman's U	0	9	0	2	—	—	—
Thiel C	2	2	—	—	—	—	—
Thomas More C	1	1	—	—	—	—	—
Toledo, U of	5	11	3	2	24	8	1
Towson State U	3	8	—	—	—	—	—
Trenton State C	13	0	—	—	—	—	—
Trinity C	10	5	0	—	—	—	—
Trinity U	1	7	—	—	—	—	—
Tri-State U[b]	—	—	—	—	22	—	—
Tufts U	0	14	2	5	41	12	0
Tulane U of Louisiana	1	4	1	2	28	4	1
Tulsa, U of	2	0	—	—	31	9	2
Tuskegee U	0	4	0	—	6	—	—
Union C	4	12	—	—	—	—	—
U.S. Air Force Academy	8	5	—	—	—	—	—
U.S. Naval Academy	20	1	—	—	—	—	—
Ursinus C	6	22	—	—	—	—	—
Utah State U	2	0	1	1	—	—	—
Utah, U of	8	32	1	16	39	0	1
Valparaiso U	6	35	—	—	—	—	—
Vanderbilt U	3	16	5	8	43	5	1
Vassar C	2	6	2	—	—	—	—
Vermont, U of	22	0	0	7	—	—	—
Villanova U	10	0	12	6	39	14	—
Virginia Commonwealth U	10	9	2	3	—	—	—
Virginia Military Institute	9	0	—	—	—	—	—
Virginia Polytechnic Institute & State U	18	11	12	13	82	17	6
Virginia, U of	12	73	6	4	37	27	3
Wabash C	2	7	—	—	—	—	—
Wagner C	0	4	—	—	—	—	—
Wake Forest U	9	17	2	0	—	—	—
Washburn U of Topeka	2	1	—	—	—	—	—
Washington C	6	0	—	—	—	—	—
Washington & Jefferson C	4	31	—	—	—	—	—
Washington & Lee U	0	9	—	—	—	—	—
Washington State U	9	12	5	15	32	5	2
Washington U	6	14	8	9	45	8	6
Washington, U of	40	16	22	16	67	14	4
Wayne State U	26	29	7	11	57	21	2
Waynesburg C	0	4	—	—	—	—	—
Weber State C	3	5	—	—	—	—	—
Wellesley C	7	22	—	—	—	—	—
Wesleyan U	4	19	1	4	—	—	—
West Chester U	5	5	5	—	—	—	—
West Florida, U of	6	5	—	—	—	—	—
West Texas State U	3	13	2	—	—	—	—
West Virginia Institute of Tech	3	0	—	—	19	2	—
West Virginia State C	1	3	—	—	—	—	—
West Virginia U	7	36	9	5	48	4	0
Western Illinois U	4	7	2	—	—	—	—
Western Kentucky U	6	10	3	—	—	—	—
Western Maryland C	1	7	—	—	—	—	—
Western Michigan U	3	13	7	1	—	—	—
Western New England C	3	0	—	—	—	—	—
Western Washington U	17	5	2	—	—	—	—
Westminster C	0	3	—	—	—	—	—
Wheaton C (Illinois)	1	14	—	—	—	—	—
Wheaton C (Massachusetts)	5	6	—	—	—	—	—
Wheeling C	0	2	—	—	—	—	—
Whitman C	6	9	—	—	—	—	—
Whittier C	1	4	—	—	—	—	—
Wichita State U	7	11	2	—	—	—	—
Widener U	0	4	—	—	—	—	—
Wilkes C	2	2	—	—	—	—	—
Willamette U	1	11	—	—	—	—	—
William Paterson C of N.J.	3	0	—	—	—	—	—
William & Mary, C of	38	5	9	—	—	—	—
Williams C	2	35	—	—	—	—	—
Wisconsin, U of							
Eau Claire	2	12	—	—	—	—	—
Green Bay	0	5	—	—	—	—	—
La Crosse	1	14	—	—	—	—	—
Madison	17	30	10	39	119	11	23
Milwaukee	3	20	9	3	—	—	—
Oshkosh	6	4	—	—	—	—	—
Parkside	3	8	—	—	—	—	—
Platteville	0	3	—	—	—	—	—
River Falls	7	12	—	—	—	—	—
Stevens Point	7	7	—	—	—	—	—
Superior	2	2	—	—	—	—	—
Wittenberg U	3	5	—	—	—	—	—
Wooster, C of	1	27	—	—	—	—	—
Worcester Polytechnic Institute	3	5	1	1	48	13	2
Wright State U	12	6	6	—	—	—	—
Wyoming, U of	0	6	4	5	14	6	0
Xavier U	2	11	5	—	—	—	—
Xavier U of Louisiana	1	20	—	—	—	—	—
Yale U	7	0	22	11	a	—	—
Youngstown State U	3	31	5	—	a	—	—
TOTALS	4021	5658	1621	1808	6442	1489	418

a Data not submitted. b Listed on basis of accreditation by AIChE-ABET. c Master's and Ph.D. degrees given by the Institute of Paper Chemistry. d The chemistry programs at Mount Saint Vincent and Manhattan College are integrated into a combined department with all instruction in chemistry located at Manhattan College. e Master's and Ph.D. degrees given by Atlanta University. Note: For brevity, B.S. and M.S. are used to denote all bachelor's and master's degrees, respectively, in each column.

Indiana new leader of graduate listing

Indiana University produced more new bachelor chemistry graduates (149) during the 1984–85 academic year than any other school in the country. Cornell University and the University of Michigan shared the lead among producers of new chemistry graduates at the masters level, each with 31. And the University of California, Berkeley, had the most new doctoral chemistry graduates with 68.

These are some of the highlights that can be gleaned from the latest report of ACS's Committee on Professional Training. The full report starts on page 43 of this issue. The committee is charged with setting standards for undergraduate programs and for monitoring them. And on an annual basis, the committee gathers statistics on new graduates at all levels from the departments it approves.

Indiana moved up from the second spot it held the previous four years to top the list of producers of new chemistry bachelor graduates in the current report. Illinois, Urbana-Champaign, the previous leader, moved down to third. And second on the new list is North Carolina, Chapel Hill, a school that topped the list in nine of the previous 11 years.

In the new report, the University of California, San Diego, and Illinois, Urbana-Champaign, share the lead among producers of new bachelor chemists with degrees certified by ACS. San Diego headed this list for the eight years ending 1980–81. Certified graduates are immediately eligible for ACS membership.

The coleaders in production of new masters chemists had both topped the list in recent years—Michigan in 1983–84 and Cornell in 1982–83.

For the past 12 years either Illinois, Urbana-Champaign (eight times), or California, Berkeley (four times), has been the largest producer of new doctoral chemists. In 1984–85 it was Berkeley's turn with Illinois second. Third was Purdue University, which moved up from ninth in 1983–84. □

These schools had the most chemistry graduates, 1984–85

Total bachelor graduates

1. Indiana U	149
2. U of North Carolina, Chapel Hill	114
3. U of Illinois, Urbana-Champaign	102
4. U of Miami	99
5. U of California, Los Angeles	97
6. U of Virginia	85
7. Emory U	83
7. U of Pittsburgh	83
9. U of South Florida	75
10. U of Maryland, College Park	74
11. U of Puerto Rico	73
12. California Polytechnic State U	70
13. Rutgers U	68
14. U of California, San Diego	63
15. U of Michigan	62
16. U of California, Irvine	56
16. New York U	56
16. State U of New York, Stony Brook	56
16. U of Washington	56
20. U of Delaware	55
20. Wayne State U	55
22. U of Colorado	53
22. Miami U	53
24. Duke U	52
24. Michigan State U	52
24. Purdue U	52
24. St. Olaf C	52

Certified bachelor graduates

1. U of California, San Diego	63
2. U of Illinois, Urbana-Champaign	63
3. U of Michigan	62
4. Rutgers U	51
5. U of California, Berkeley	49
6. U of Texas	42
7. U of Minnesota	41
8. U of Washington	40
9. U of Delaware	39
10. C of William & Mary	38
11. Ohio State U	36
12. U of North Carolina, Chapel Hill	34
13. Illinois State U	31
13. Michigan State U	31
15. U of Cincinnati	30
15. Purdue U	30
17. U of California, Los Angeles	29
17. Indiana U	29
19. Boston C	27
19. Princeton U	27
19. U of Puerto Rico, Mayaguez	27
22. Carnegie-Mellon U	26
22. San Jose State U	26
22. Wayne State U	26
25. U of California, Davis	25
25. Massachusetts Inst of Tech	25
25. State U of New York, Stony Brook	25

Masters graduates

1. Cornell U	31
1. U of Michigan	31
3. Columbia U	26
4. Rensselaer Polytechnic Inst	25
4. U of Rochester	25
6. U of Washington	22
6. Yale U	22
8. U of California, San Diego	20
9. U of Illinois, Chicago	19
10. Ohio State U	18
11. U of California, Los Angeles	17
12. Northwestern U	16
12. U of Oklahoma	16
14. U of Scranton	15
15. Drexel U	14
15. Lawrence U*	14
15. U of Minnesota	14
15. New York U	14
15. Princeton U	14
15. Purdue U	14
15. Rutgers U, Newark C	14
22. U of Cincinnati	13
22. U of Maryland, College Park	13
24. U of Illinois, Urbana-Champaign	12
24. Lehigh U	12
24. San Jose State U	12
24. Villanova U	12
24. Virginia Polytechnic Inst	12

Doctoral graduates

1. U of California, Berkeley	68
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* Degrees given by the Institute of Paper Chemistry.

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NEWS

George Keyworth reflects on science advisory role
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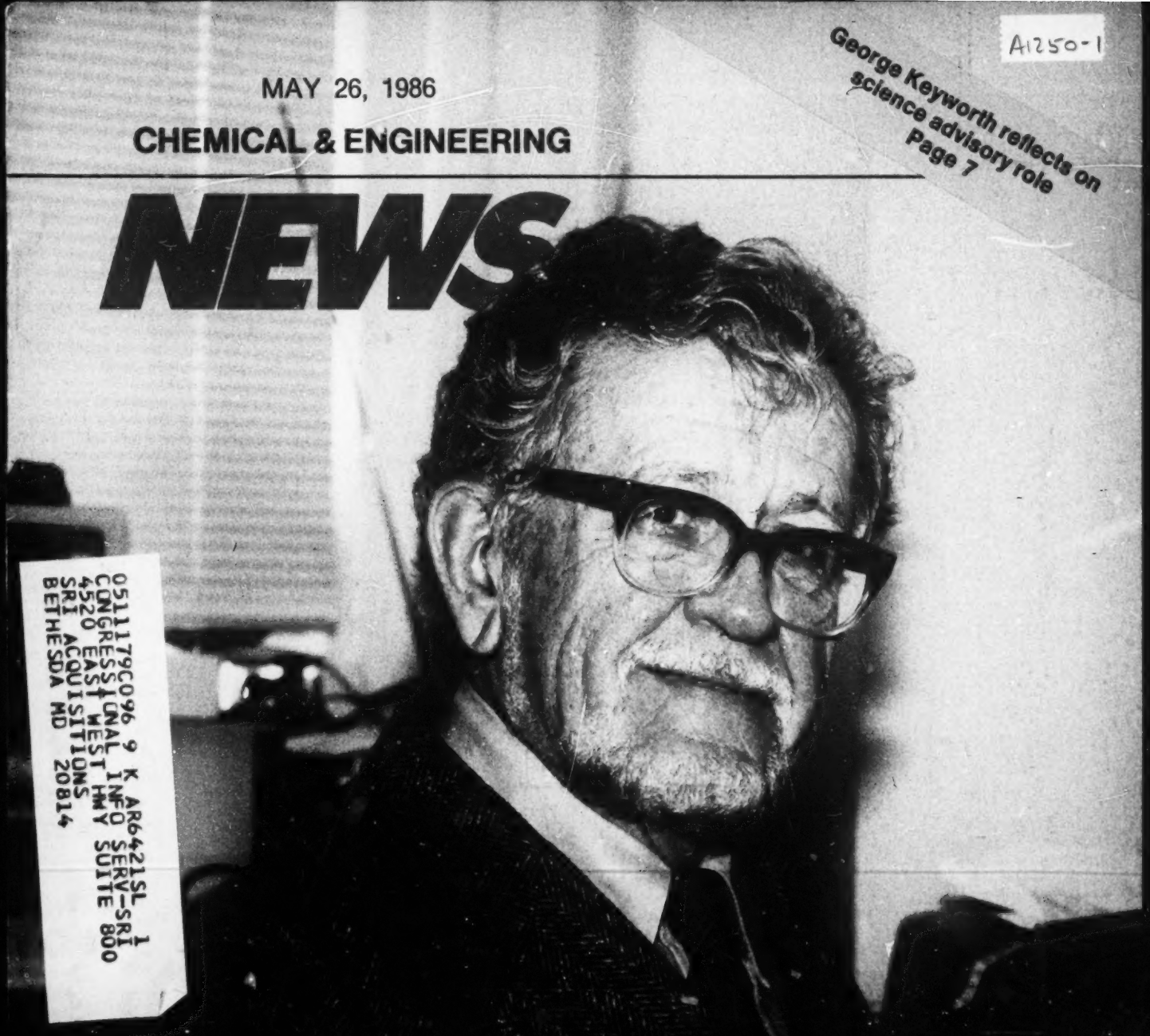

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John D. Roberts wins 1987 Priestley Medal

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NEWS

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■ **NRC's Space Science Board calls for diversification of space effort, including return to use of unmanned vehicles.** **Page 4**

■ **Commerce's International Trade Administration proposes new rules governing export of scientific and technical data.** **Page 5**

■ **Supreme Court rules EPA's aerial photographing of Dow plant was legal.** **Page 5**

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■ **Joint venture of Occidental Petroleum and Drexel Burnham Lambert to buy Diamond Shamrock Chemicals.** **Page 6**

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Business

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U.S. pharmaceutical firms had higher sales and profits thanks to the weakening of the dollar against foreign currencies. **Page 17**

The catalyst business, growing at a slow 3%-a-year pace, is by no means mature, rather is on the lookout for new markets. **Page 18**

Higher demand for pulp and paper and new technologies will boost the need for both new and different chemicals in papermaking. **Page 19**

Government

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Priestley Medal

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Education

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News Focus

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Pharmaceutical earnings aided by weaker dollar

The weakening of the U.S. dollar against other currencies helped U.S. pharmaceutical and medical supply firms record strong increases in sales and net income in the first quarter of 1986. For many companies, more favorable exchange rates, along with increases in sales volume, translated into greater growth in sales revenues overseas than in the U.S.

A group of 16 companies, most of which depend on foreign sales for a large percentage of their revenues, reported a composite gain of 15% in after-tax earnings for the first quarter on a 17% rise in sales, compared with last year's first quarter. The group's composite profit margin (after-tax income as a percentage of sales) fell slightly to 12.1% from 12.4% in first-quarter 1985.

Net income rose most sharply at Becton Dickinson, up 41% (before an extraordinary tax credit) on an 11% increase in sales. The greatest share of the sales rise occurred overseas, where revenues increased $19 million, or 27%. The revitalization of local currencies against the dollar had a clear impact: Some $15 million of the international area's sales increase resulted from more favorable exchange rates. And the new situation also had its effect on the bottom line. Net income was about 16% higher than it would have been had the dollar remained at year-earlier exchange rates.

The weaker dollar also helped Squibb record a 23% increase in sales. Sales for the company's largest business segment, the pharmaceutical products group, rose 26%, but would have been up 23% if not for the change in exchange rates. Similarly, sales for the second-largest segment, medical products, increased 33%, but would have been up 27% without the more favorable rates. The company's personal care products group turned in a 9% sales gain. The increase would have been just 3% at year-earlier dollar values. Squibb's net income grew 27% in the first quarter, the second best gain in the 16-company group.

For Baxter Travenol, which acquired American Hospital Supply late last year, net income rose 26% on a 168% jump in sales. Much of that sales increase stems from the recent merger; first-quarter 1985 results were not restated to reflect it. Chief executive officer Vernon R. Loucks Jr. says the acquisition, which greatly expanded the company's range of products, was instrumental in enabling the company to prosper in a hospital supply market still characterized by strong cost-containment measures on the part of customers. The weaker dollar also helped Baxter Travenol. According to the company, nearly 10% of its $259 million in international sales in the first quarter was due to more favorable exchange rates.

At Schering-Plough, net income increased 20% on a 15% sales rise. The chief reason was growth in sales volume, according to Robert P. Luciano, chairman and chief executive officer. The gains were led by the U.S. pharmaceutical business, the international pharmaceutical operation—particularly in Europe and Latin America—and the sun care line.

Merck reported a 20% rise in net income. More favorable exchange rates boosted revenues 8% higher than they would have been at last year's dollar value (sales outside the U.S. accounted for 46% of all first-quarter sales), and sales volume increases were achieved in many product lines. Sales increased just 8% overall, however, because first-quarter 1985 figures include results for two subsidiaries, Calgon Carbon and Baltimore Aircoil, that were divested in second-quarter 1985.

Bristol-Myers' net earnings rose 18% on a 10% increase in sales. Through a restatement of first-quarter 1985 results, those figures account for the first-quarter 1986 acquisition of the Seattle biotechnology company, Genetic Systems. Like many other companies in the group, Bristol-Myers reported a greater gain in sales overseas, up 17%, than in the U.S., up 8%, during the first quarter.

Pfizer's net income increased 15% on an 8% rise in sales. The results, which are restated for first-quarter 1985 to reflect the May 1985 acquisition of American Medical Systems, were helped by currency exchange rates. Sales would have grown only 5% at the dollar's level a year earlier. Pharmaceutical sales, for example, increased 5% in the U.S. but 18% overseas. Pfizer recorded sales gains in health care, up 12%; specialty chemicals, up 6%; materials science, up 6%; and consumer products, up 5%. The company's agriculture segment, however, reported a 7% decline in sales.

David Webber, New York

Drug industry income rose 15% in first quarter

	Sales	Earnings[a]	Change from 1985		Profit margin[b]	
	($ millions)		Sales	Earnings	1986	1985
Abbott Labs	$ 865.5	$123.5	14%	21%	14.3%	13.5%
American Home Products	1264.7	196.9	5	9	15.6	15.0
Avon Products	608.5	15.7	15	15	2.6	2.6
Baxter Travenol	1367.0	49.0	168	26	3.6	7.6
Becton Dickinson	319.1	31.1	11	41	9.8	7.7
Bristol-Myers	1194.5	144.6	10	18	12.1	11.4
Lilly	988.3	172.6	9	7	17.5	17.7
Merck	921.1	157.8	8	20	17.1	15.4
Pfizer	1032.1	168.9	8	15	16.4	15.5
A. H. Robins	191.4	23.2	15	8	12.1	12.9
Schering-Plough	562.3	65.0	15	20	11.6	11.1
SmithKline Beckman	863.1	145.3	12	10	16.8	17.1
Squibb	558.9	53.6	23	27	9.6	9.3
Sterling Drug	420.2	35.4	7	11	8.4	8.1
Upjohn	537.4	63.0	13	15	11.7	11.5
Warner-Lambert	746.9	65.1	−6	9	8.7	7.5

a Excludes significant extraordinary and nonrecurring items. b After-tax earnings as a percentage of sales.